IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the matter of an application for a German Patent

in the name of Merck Patent GmbH, Darmstadt, Germany,
filed under No. 102 54 598.7
on 22 November 2002

and in the matter of an application for a United States Patent.

I, Dr. Ashwood Stephen DRANE, B.Sc., Ph.D., BDÜ, translator to SD Translations Ltd. of Beechwood, Chivery, Tring, Hertfordshire, HP23 6LD, England, do solemnly and sincerely declare:

1. That I am a citizen of the United Kingdom of Great Britain and Northern Ireland.
2. That I am well acquainted with the German and English languages and am a competent translator thereof.
3. That the following is to the best of my knowledge and belief a true and correct translation of the above-referenced patent application and the Official Certificate attached thereto

Dated this 24th day of August 2007

Dr. Ashwood Stephen Drane

FEDERAL REPUBLIC OF GERMANY

Priority certificate regarding the filing of a patent application

File reference: 102 54 598.7

Date of filing: 22 November 2002

Applicant/proprietor: Merck Patent GmbH, Darmstadt/DE

Title: Liquid-crystalline medium

IPC: C 09 K, G 02 F

The attached pages are a correct and accurate reproduction of the original documents of this patent application.

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The President

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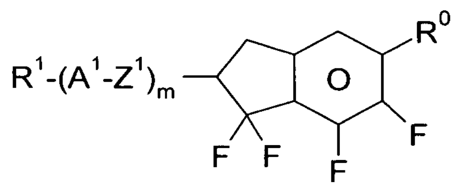
64271 D a r m s t a d t

Liquid-crystalline medium

Liquid-crystalline medium

The invention relates to a liquid-crystalline medium based on a mixture of polar compounds having negative dielectric anisotropy, which comprises at least one compound of the formula I



I

in which

R^0 and R^1 each, independently of one another, denote H, an alkyl or alkenyl radical having up to 15 C atoms which is unsubstituted, monosubstituted by CN or CF_3 or at least monosubstituted by halogen, where, in addition, one or more CH_2 groups in these radicals may be replaced by -O-, -S-,  , -C≡C-, -OC-O- or -O-CO- in such a way that O atoms are not linked directly to one another,

A^1

a) denotes a 1,4-cyclohexenylene or 1,4-cyclohexylene radical, in which one or two non-adjacent CH_2 groups may be replaced by -O- or -S-,

b) denotes a 1,4-phenylene radical, in which one or two CH groups may be replaced by N,

c) denotes a radical from the group consisting of piperidine-1,4-diyl-, 1,4-bicyclo[2.2.2]octylene-, a naphthalene-2,6-diyl, decahydronaphthalene-2,6-diyl, 1,2,3,4-tetrahydro-naphthalene-2,6-diyl, phenanthrene-2,7-diyl and fluorene-2,7-diyl,

where the radicals a), b) and c) may be mono- or polysubstituted by halogen atoms,

Z^1 denotes -CO-O-, -O-CO-, $-CF_2O-$, $-OCF_2-$, $-CH_2O-$, $-OCH_2-$, $-CH_2CH_2-$, $-(CH_2)_4-$, $-C_2F_4-$, $-CH_2CF_2-$, $-CF_2CH_2-$, -CF=CF-, -CH=CF-, -CF=CH-, -CH=CF-, -CF=CH-, -CH=CH-, -C≡C- or a single bond, and

m denotes 0, 1 or 2.

Media of this type are to be used, in particular, for electro-optical displays with active-matrix addressing based on the ECB effect and for IPS (in plane switching) displays.

The principle of electrically controlled birefringence, the ECB (electrically controlled birefringence) effect or DAP (deformation of aligned phases) effect was described for the first time in 1971 (M.F. Schieckel and K. Fahrenschon, "Deformation of nematic liquid crystals with vertical orientation in electrical fields", Appl. Phys. Lett. 19 (1971), 3912). Papers by J.F. Kahn (Appl. Phys. Lett. 20 (1972), 1193) and G. Labrunie and J. Robert (J. Appl. Phys. 44 (1973), 4869) followed.

The papers by J. Robert and F. Clerc (SID 80 Digest Techn. Papers (1980), 30), J. Duchene (Displays 7 (1986), 3) and H. Schad (SID 82 Digest Techn. Papers (1982), 244) have shown that liquid-crystalline phases must have high values for the ratio between the elastic constants K_3/K_1, high values for the optical anisotropy Δn and values for the dielectric anisotropy $\Delta\varepsilon$ of -0.5 to -5 in order to be suitable for use in high-information display elements based on the ECB effect. Electro-optical display elements based on the ECB effect have a homeotropic edge alignment. Dielectrically negative liquid-crystal media can also be used in displays which use the so-called IPS effect.

Industrial application of this effect in electro-optical display elements requires LC phases which have to satisfy a multiplicity of requirements. Particularly important here are chemical resistance to moisture, air and

physical influences, such as heat, radiation in the infrared, visible and ultraviolet regions, and direct and alternating electric fields.

Furthermore, LC phases which can be used industrially are required to have a liquid-crystalline mesophase in a suitable temperature range and low viscosity.

None of the series of compounds having a liquid-crystalline mesophase that have been disclosed hitherto includes a single compound which meets all these requirements. Mixtures of two to 25, preferably three to 18, compounds are therefore generally prepared in order to obtain substances which can be used as LC phases. However, it has not been possible to prepare optimum phases easily in this manner, since no liquid-crystal materials having significantly negative dielectric anisotropy and adequate long-term stability have hitherto been available.

Matrix liquid-crystal displays (MLC displays) are known. Non-linear elements which can be used for individual switching of the individual pixels are, for example, active elements (i.e. transistors). The term “active matrix” is then used, where a distinction can be made between two types:

1. MOS (metal oxide semiconductor) transistors on a silicon wafer as substrate.

2. Thin-film transistors (TFTs) on a glass plate as substrate.

In type 1, the electro-optical effect used is usually dynamic scattering or the guest-host effect. The use of single-crystal silicon as substrate material restricts the display size, since even modular assembly of various part-displays results in problems at the joins.

In the case of the more promising type 2, which is preferred, the electro-optical effect used is usually the TN effect.

A distinction is made between two technologies: TFTs comprising compound semiconductors, such as, for example, CdSe, or TFTs based on

polycrystalline or amorphous silicon. The latter technology is being worked on intensively worldwide.

The TFT matrix is applied to the inside of one glass plate of the display, while the other glass plate carries the transparent counterelectrode on its inside. Compared with the size of the pixel electrode, the TFT is very small and has virtually no adverse effect on the image. This technology can also be extended to fully colour-compable displays, in which a mosaic of red, green and blue filters is arranged in such a way that a filter element is opposite each switchable pixel.

The TFT displays disclosed hitherto usually operate as TN cells with crossed polarisers in transmission and are back-lit.

The term MLC displays here covers any matrix display with integrated non-linear elements, i.e. besides the active matrix, also displays with passive elements, such as varistors or diodes (MIM = metal-insulator-metal).

MLC displays of this type are particularly suitable for TV applications (for example pocket TVs) or for high-information displays in automobile or aircraft construction. Besides problems regarding the angle dependence of the contrast and the response times, difficulties also arise in MLC displays due to insufficiently high specific resistance of the liquid-crystal mixtures [TOGASHI, S., SEKIGUCHI, K., TANABE, H., YAMAMOTO, E., SORI-MACHI, K., TAJIMA, E., WATANABE, H., SHIMIZU, H., Proc. Eurodisplay 84, Sept. 1984: A 210-288 Matrix LCD Controlled by Double Stage Diode Rings, pp. 141 ff., Paris; STROMER, M., Proc. Eurodisplay 84, Sept. 1984: Design of Thin Film Transistors for Matrix Addressing of Television Liquid Crystal Displays, pp. 145 ff., Paris]. With decreasing resistance, the contrast of an MLC display deteriorates. Since the specific resistance of the liquid-crystal mixture generally drops over the life of an MLC display owing to interaction with the inside surfaces of the display, a high (initial) resistance is very important for displays that have to have acceptable resistance values over a long operating period.

The disadvantage of the MLC-TN displays disclosed hitherto is due to their comparatively low contrast, the relatively high viewing-angle dependence and the difficulty of producing grey shades in these displays.

There thus continues to be a great demand for MLC displays having very high specific resistance at the same time as a wide operating-temperature range, short response times and low threshold voltage with the aid of which various grey shades can be produced.

The invention has the object of providing MLC displays which are based on the ECB or IPS effect and do not have the disadvantages indicated above, or only do so to a lesser extent, and at the same time have very high specific resistance values.

It has now been found that this object can be achieved if nematic liquid-crystal mixtures which comprise at least one compound of the formula I are used in these display elements.

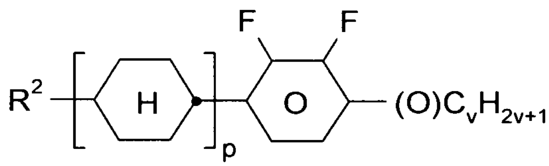
The invention thus relates to a liquid-crystalline medium based on a mixture of polar compounds having negative dielectric anisotropy which comprises at least one compound of the formula I.

Compounds of the formula I are known, for example, from EP 0 637 585 A1. The liquid-crystalline mixtures described in the prior art are exclusively intended for ferroelectric applications. The use of fluorinated indanes for ECB or IPS displays is not known.

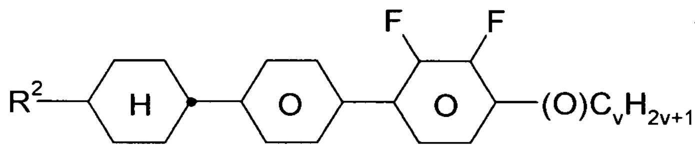
The mixtures according to the invention exhibit very favourable values for the capacitive threshold, relatively high values for the holding ratio and at the same time very good low-temperature stability as well as very low rotational viscosities.

Some preferred embodiments are indicated below:

a) Liquid-crystalline medium which additionally comprises one or more compounds of the formulae IIA and/or IIB



IIA

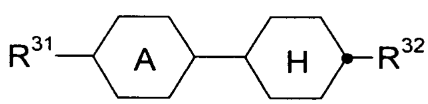


IIB

in which

R^2	has the meaning of R^1,
p	denotes 1 or 2, and
v	denotes 1 to 6.

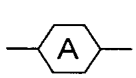
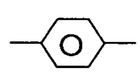
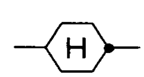
b) Liquid-crystalline medium which additionally comprises one or more compounds of the formula III



III

in which

R^{31} and R^{32} each, independently of one another, denote a straight-chain alkyl, alkylalkoxy or alkoxy radical having up to 12 C atoms, and

 denotes  or  .

c) Liquid-crystalline medium which comprises one, two, three, four or more, preferably one or two, compounds of the formula I.

d) Liquid-crystalline medium in which R^1 in the formula I preferably has the following meanings: straight-chain alkyl, vinyl, 1E-alkenyl or 3-alkenyl.

If R^1 denotes alkenyl, it is preferably CH_2=CH, CH_3-CH=CH, C_3H_7-CH=CH, CH_2=CH-C_2H_5 or CH_3-CH=CH-C_2H_5.

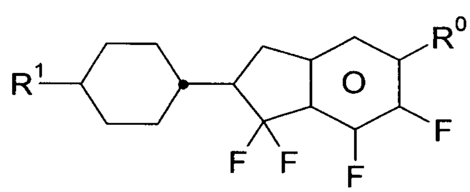
R^0 preferably denotes H or straight-chain alkyl having 1 to 6 C atoms, in particular methyl, ethyl or propyl.

e) Liquid-crystalline medium in which the proportion of compounds of the formula I in the mixture as a whole is at least 5% by weight, preferably at least 10% by weight.

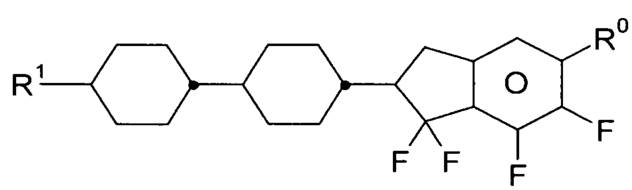
f) Liquid-crystalline medium in which the proportion of compounds of the formulae IIA and/or IIB in the mixture as a whole is at least 20% by weight.

g) Liquid-crystalline medium in which the proportion the compounds of the formula III in the mixture as a whole is at least 5% by weight.

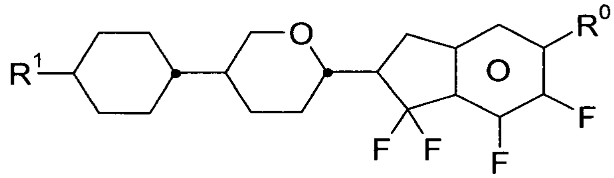
h) Liquid-crystalline medium which comprises at least one compound selected from the sub-formulae I1 to I12:



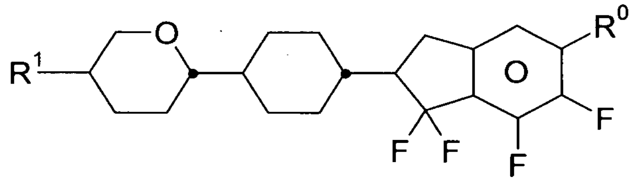
I1



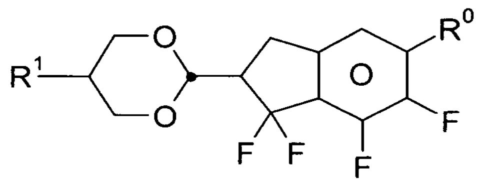
I2



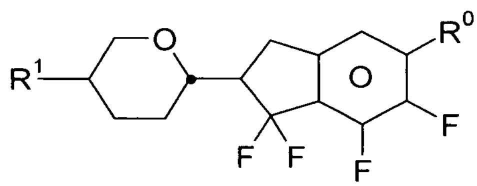
I3



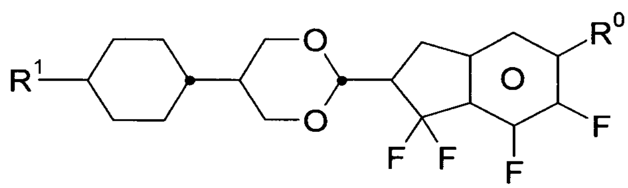
I4



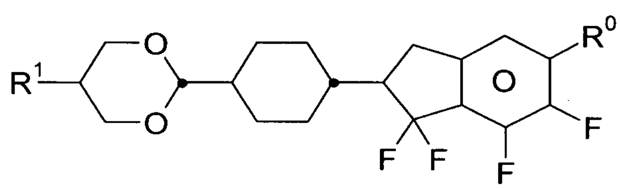
I5



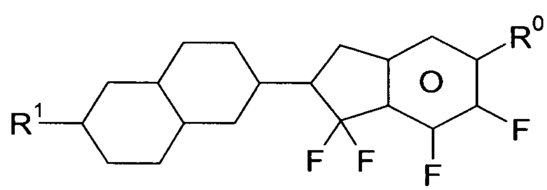
I6



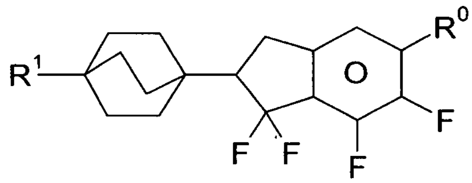
I7



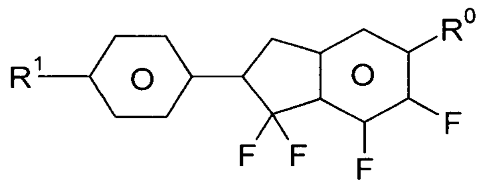
I8



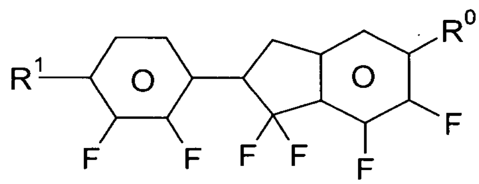
I9



I10

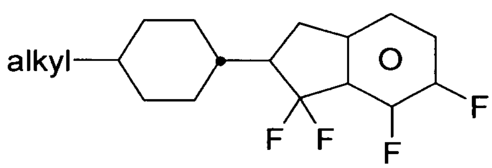


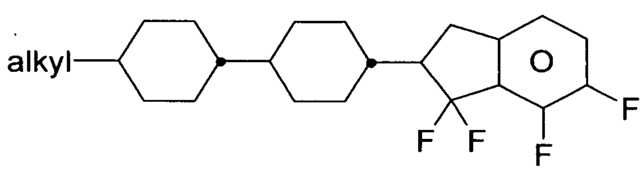
I11

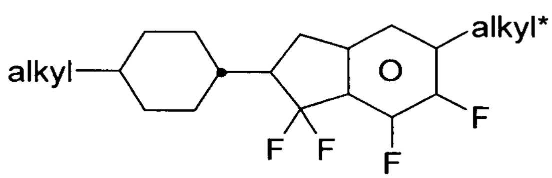


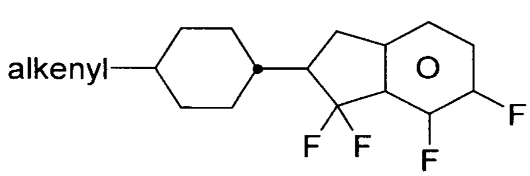
I12

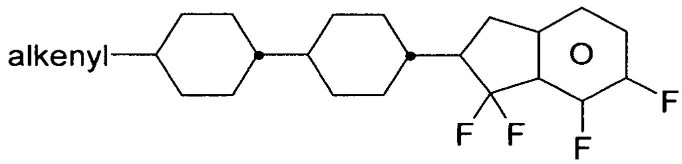
Particularly preferred media comprise one or more compounds selected from the group consisting of the compounds of the formulae

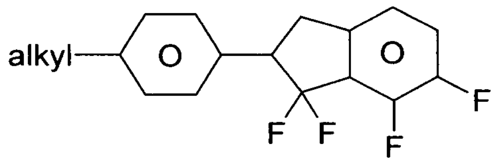


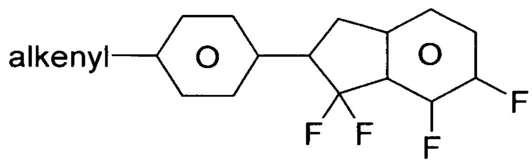






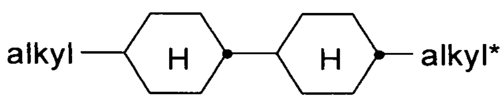




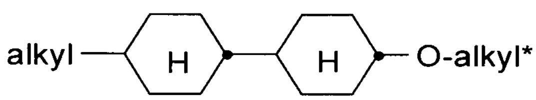


Particular preference is given to media which comprise at least one compound of the formula Ia.

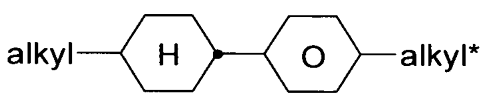
i) Liquid-crystalline medium which additionally comprises a compound selected from the formulae IIIa to IIIf:



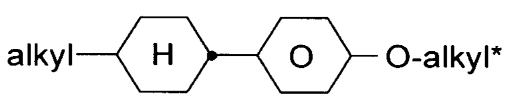
IIIa



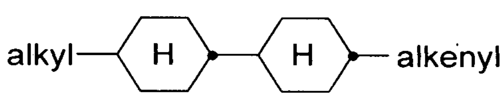
IIIb



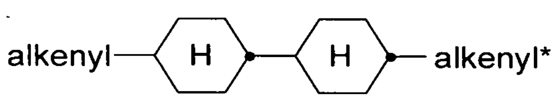
IIIc



IIId



IIIe



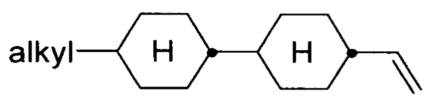
IIIf

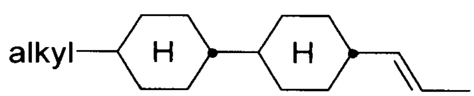
in which

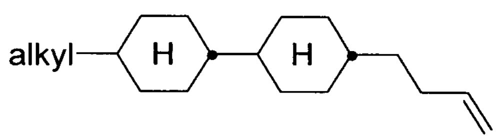
alkyl and alkyl*	each, independently of one another, denote a straight-chain alkyl radical having 1-6 C atoms, and
alkenyl and alkenyl*	each, independently of one another, denote a straight-chain alkenyl radical having 2-6 C atoms.

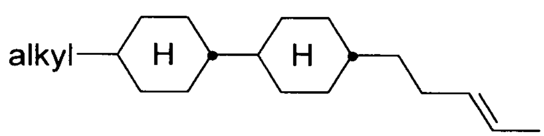
The medium according to the invention preferably comprises at least one compound of the formula IIIa, formula IIIb and/or formula IIIe.

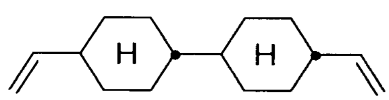
Particularly preferred compounds of the formulae IIIe and IIIf are indicated below:

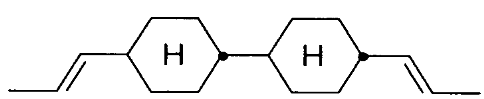


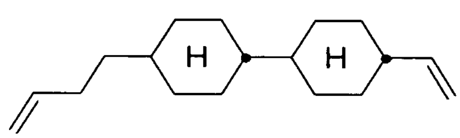


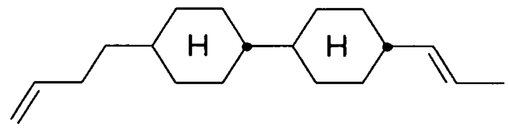


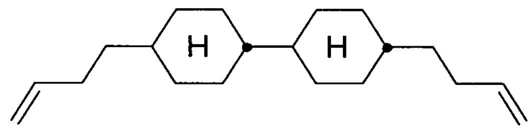










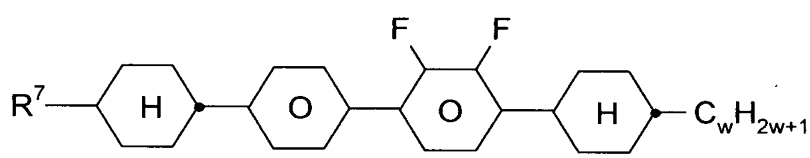


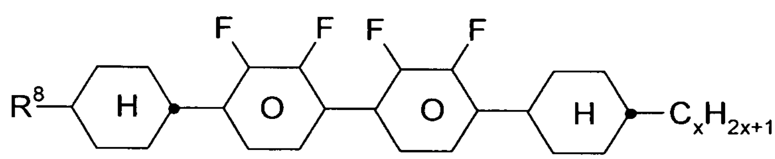
j) Liquid-crystalline medium which essentially consists of:

5-30 % by weight of one or more compounds of the formula I and

20-70 % by weight of one or more compounds of the formulae IIA and/or IIB.

k) Liquid-crystalline medium which additionally comprises one or more tetracyclic compounds of the formulae



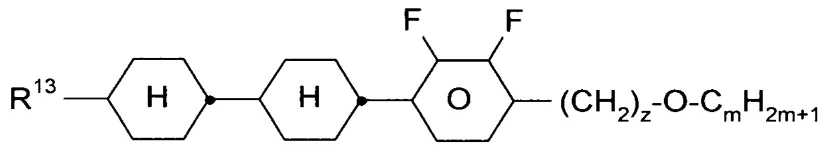


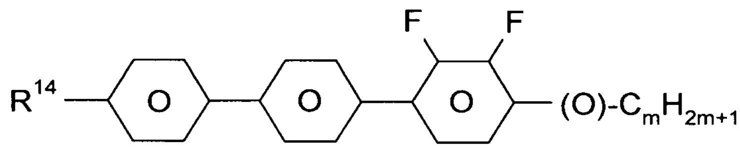
in which

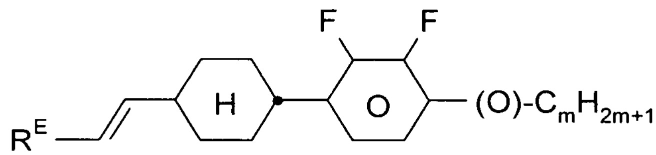
R^7 and R^8 each, independently of one another, have one of the meaning indicated for R^1 in Claim 1, and

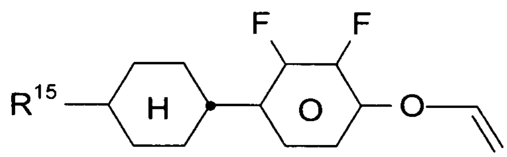
w and x each, independently of one another, denote 1 to 6.

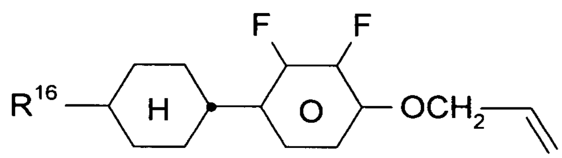
l) Liquid-crystalline medium which additionally comprises one or more compounds of the formulae

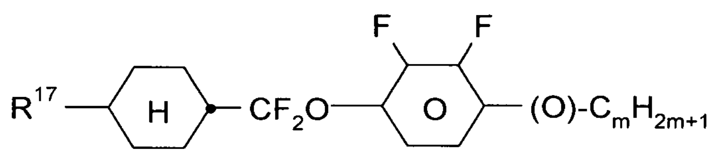


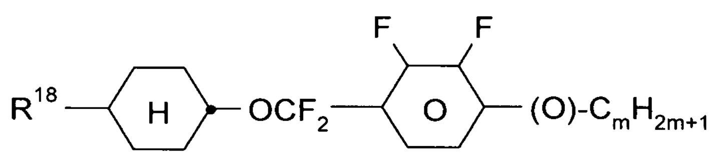


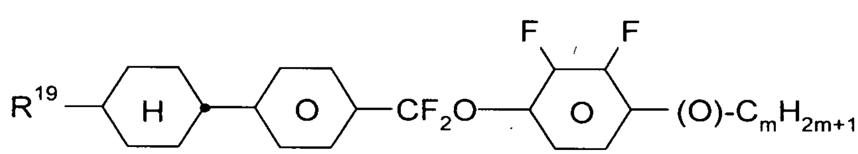


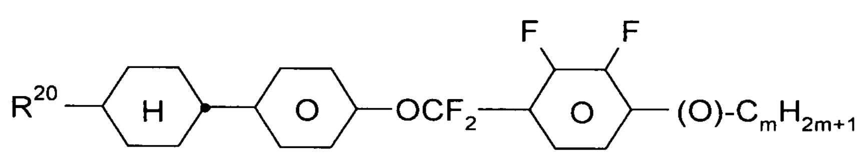


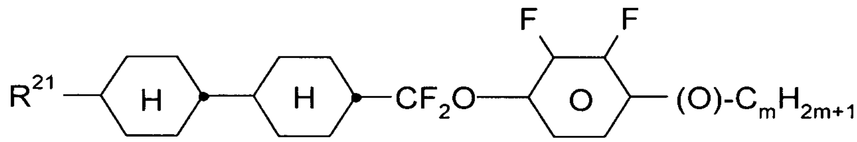


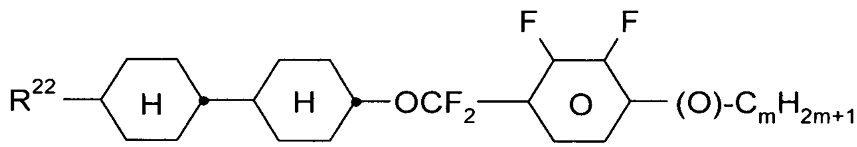


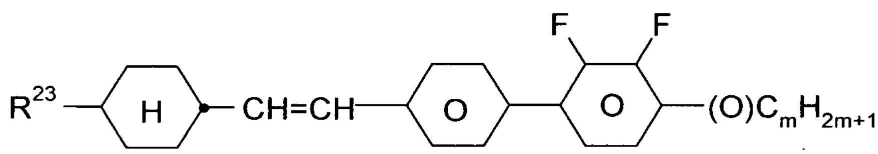


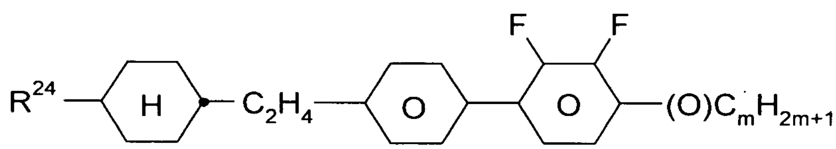


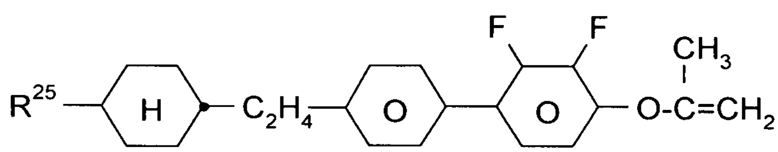


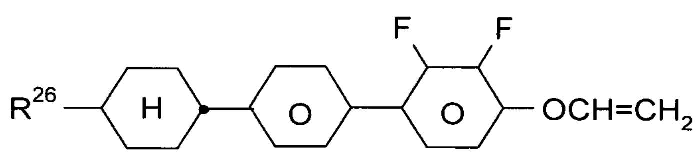


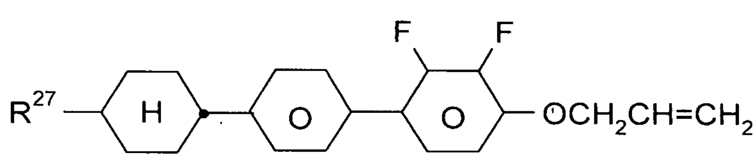


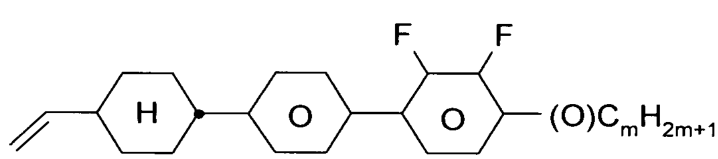






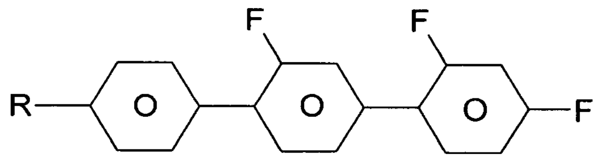


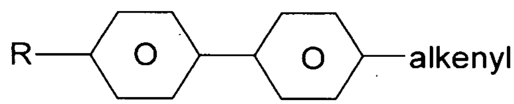




in which R^{13}-R^{27} each, independently of one another, have the meanings indicated for R^1, and z and m each, independently of one another, denote 1-6. R^E denotes H, CH_3, C_2H_5 or n-C_3H_7.

m) Liquid-crystalline medium additionally comprising one or more compounds of the formulae





in which R denotes alkyl, alkenyl, alkoxy, alkylalkoxy or alkenyloxy having 1 or 2 to 6 C atoms, and alkenyl has the meaning indicated above.

The invention furthermore relates to an electro-optical display with active-matrix addressing based on the ECB effect, characterised in that it contains, as dielectric, a liquid-crystalline medium according to one of Claims 1 to 9.

The liquid-crystal mixture preferably has a nematic phase range of at least 60 K and a flow viscosity ν_{20} of at most 30 $mm^2 \cdot s^{-1}$ at 20°C.

The liquid-crystal mixture according to the invention has a $\Delta\varepsilon$ of about -0.5 to -8.0, in particular about -3.0 to -6.0, where $\Delta\varepsilon$ denotes the dielectric anisotropy. The rotational viscosity γ_1 is preferably < 150 mPa·s, in particular < 140 mPa·s.

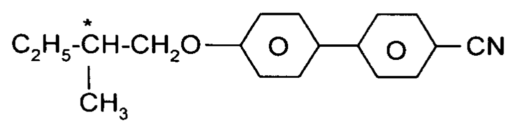
The birefringence Δn in the liquid-crystal mixture is generally between 0.07 and 0.15, preferably between 0.08 and 0.10.

The mixtures according to the invention are suitable for all VA-TFT applications, such as, for example, MVA, PVA and ASV. They are furthermore suitable for IPS and PALC applications with negative $\Delta\varepsilon$.

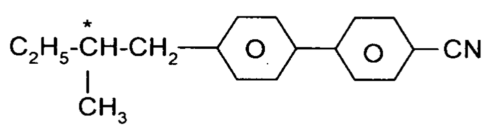
The dielectrics may also comprise further additives known to the person skilled in the art and described in the literature.

For example, 0-15% of pleochroic dyes may be added, furthermore conductive salts, preferably ethyldimethyldodecylammonium 4-hexoxybenzoate, tetrabutylammonium tetraphenylboranate or complex salts of crown ethers (cf., for example, Haller et al., Mol. Cryst. Liq. Cryst. Volume 24, pages 249-258 (1973)) in order to improve the conductivity or substances may be added in order to modify the dielectric anisotropy, the viscosity and/or the alignment of the nematic phases. Substances of this type are described, for example, in DE-A 22 09 127, 22 40 864, 23 21 632, 23 38 281, 24 50 088, 26 37 430 and 28 53 728.

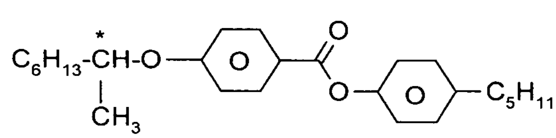
Dopants which can be added to the mixtures according to the invention are indicated below:



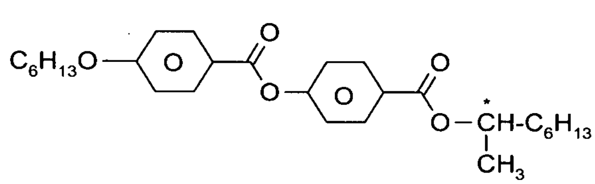
C 15



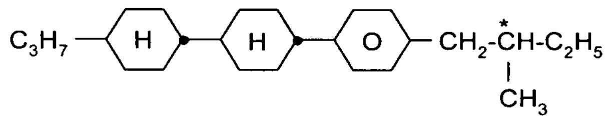
CB 15



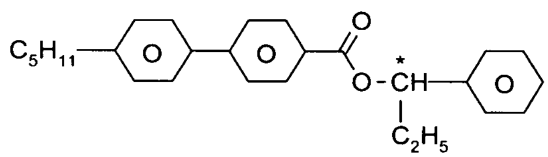
CM 21



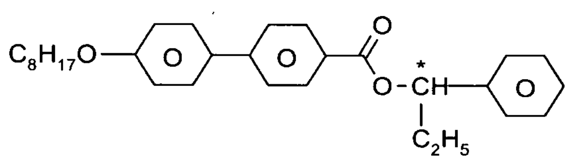
R/S-811



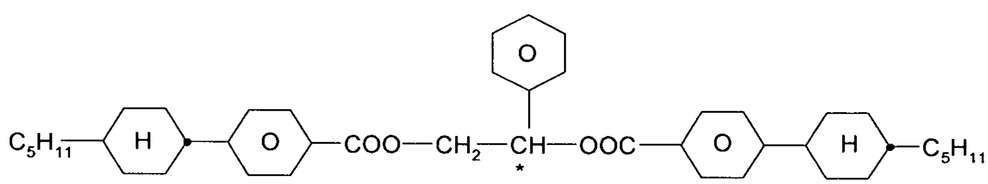
CM 44



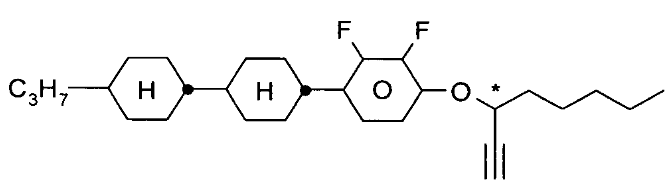
CM 45



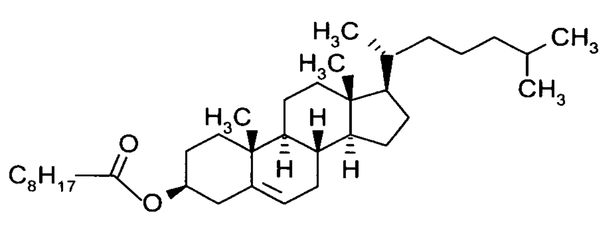
CM 47



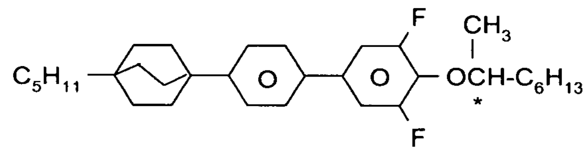
R/S-1011



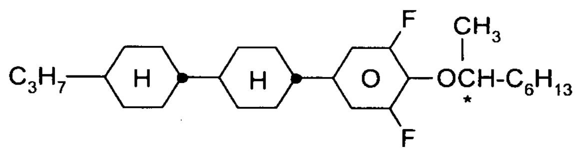
R/S-3011



CN



R/S-4011



R/S-2011

The individual components of the formulae I, IIA, IIB and III of the liquid-crystal phases according to the invention are either known or their methods of preparation can easily be derived from the prior art by the person skilled in the relevant art since they are based on standard methods described in the literature.

The nematic liquid-crystal mixtures in the displays according to the invention generally comprise two components A and B, which themselves consist of one or more individual compounds.

Component A has significantly negative dielectric anisotropy and gives the nematic phase a dielectric anisotropy of ≤ -0.3. It preferably comprises compounds of the formulae I, IIA and/or IIB.

The proportion of component A is preferably between 45 and 100%, in particular between 60 and 100%.

For component A, one (or more) individual compound(s) which has (have) a value of $\Delta\varepsilon$ of ≤ -0.8 is (are) preferably selected. This value must be more negative the smaller the proportion A in the mixture as a whole.

Component B has pronounced nematogeneity and a flow viscosity of not greater than 30 $mm^2 \cdot s^{-1}$, preferably not greater than 25 $mm^2 \cdot s^{-1}$, at 20°C.

Particularly preferred individual compounds in component B are extremely low-viscosity nematic liquid crystals having a flow viscosity of not greater than 18 $mm^2 \cdot s^{-1}$, preferably not greater than 12 $mm^2 \cdot s^{-1}$, at 20°C.

Component B is monotropically or enantiotropically nematic, has no smectic phases and is able to prevent the occurrence of smectic phases down to very low temperatures in liquid-crystal mixtures. For example, if various materials of high nematogeneity are added to a smectic liquid-crystal mixture, the nematogeneity of these materials can be compared through the degree of suppression of smectic phases that is achieved.

A multiplicity of suitable materials is known to the person skilled in the art from the literature. Particular preference is given to compounds of the formula III.

In addition, these liquid-crystal phases may also comprise more than 18 components, preferably 18 to 25 components.

The phases preferably comprise 4 to 15, in particular 5 to 12, compounds of the formulae I, IIA and/or IIB and optionally III.

Besides compounds of the formulae I, IIA and/or IIB and III, other constituents may also be present, for example in an amount of up to 45% of the mixture as a whole, but preferably up to 35%, in particular up to 10%.

The other constituents are preferably selected from nematic or nematogenic substances, in particular known substances, from the classes of the azoxybenzenes, benzylideneanilines, biphenyls, terphenyls, phenyl or cyclohexyl benzoates, phenyl or cyclohexyl cyclohexanecarboxylates, phenylcyclohexanes, cyclohexylbiphenyls, cyclohexylcyclohexanes, cyclohexylnaphthalenes, 1,4-biscyclohexylbiphenyls or cyclohexylpyrimidines, phenyl- or cyclohexyldioxanes, optionally halogenated stilbenes, benzyl phenyl ethers, tolans and substituted cinnamic acids.

The most important compounds which are suitable as constituents of liquid-crystal phases of this type can be characterised by the formula IV

$$R^9\text{-L-G-E-}R^{10} \qquad \text{IV}$$

in which L and E each denote a carbocyclic or heterocyclic ring system from the group formed by 1,4-disubstituted benzene and cyclohexane rings, 4,4'-disubstituted biphenyl, phenylcyclohexane and cyclohexylcyclohexane systems, 2,5-disubstituted pyrimidine and 1,3-dioxane rings, 2,6-disubstituted naphthalene, di- and tetrahydronaphthalene, quinazoline and tetrahydroquinazoline,

G is	-CH=CH-	-N(O)=N-
	-CH-CQ-	-CH=N(O)-
	-C≡C-	$-CH_2-CH_2-$
	-CO-O-	$-CH_2-O-$
	-CO-S-	$-CH_2-S-$
	-CH=N-	-COO-Phe-COO-
	$-CF_2O-$	-CF=CF-

or a C-C single bond, Q denotes halogen, preferably chlorine, or -CN, and R^9 and R^{10} each denote alkyl, alkenyl, alkoxy, alkanoyloxy or alkoxycarbonyloxy having up to 18, preferably up to 8 carbon atoms, or one of these radicals alternatively denotes CN, NC, NO_2, NCS, CF_3, F, Cl or Br.

In most of these compounds, R^9 and R^{10} are different from one another, one of these radicals usually being an alkyl or alkoxy group. Other variants of the proposed substituents are common. Many such substances or also mixtures thereof are also commercially available. All these substances can be prepared by methods known from the literature.

It goes without saying for the person skilled in the art that the VA, IPS or PALC mixture according to the invention may also comprise compounds in which, for example, H, N, O, Cl and F have been replaced by the corresponding isotopes.

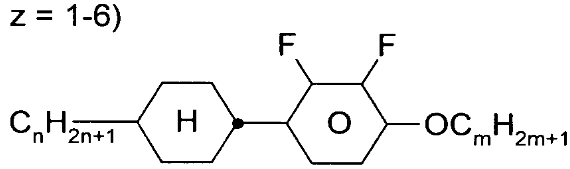
The construction of the liquid-crystal displays according to the invention corresponds to the usual geometry, as described, for example, in EP-A 0 240 379.

The following examples are intended to explain the invention without limiting it. Above and below, percentages are per cent by weight; all temperatures are indicated in degrees Celsius.

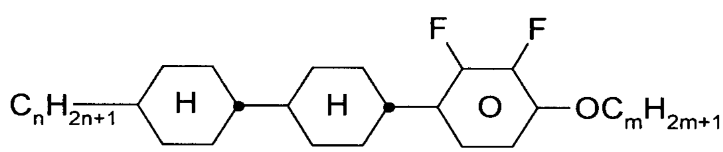
Besides the compounds of the formula I, the mixtures according to the invention preferably comprise one or more of the compounds shown below.

The following abbreviations are used:
(n and m = 1-6; z = 1-6)

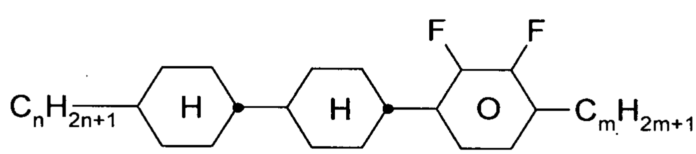
CY-n-Om



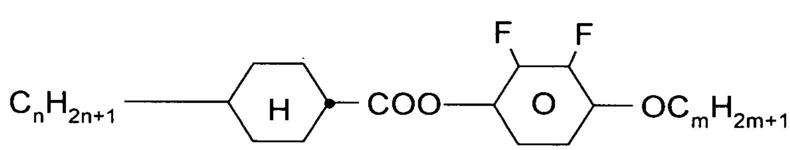
CCY-n-Om



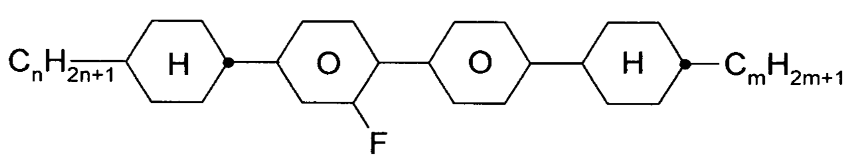
CCY-n-m

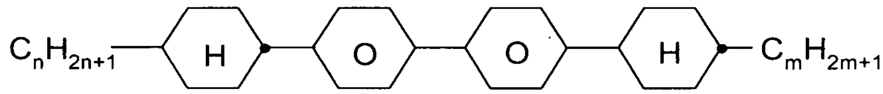


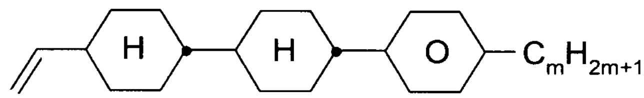
D-nOmFF

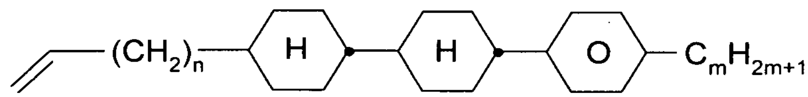


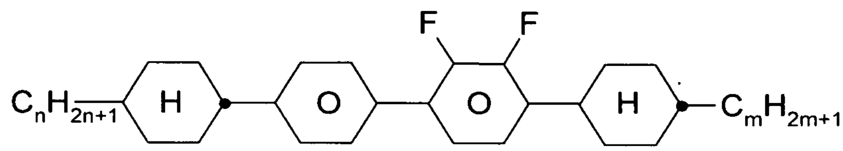
CBC-nmF

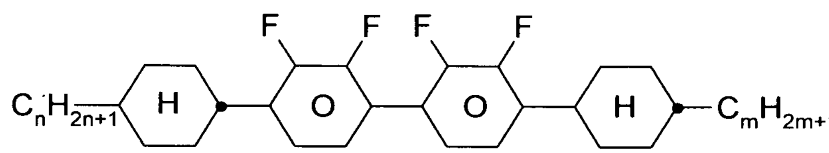


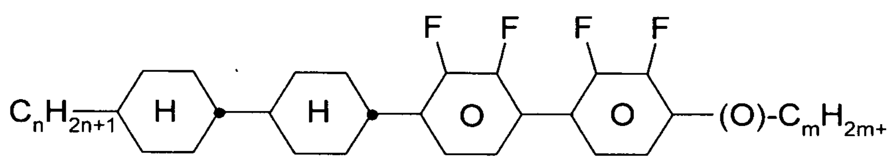
CBC-nm 

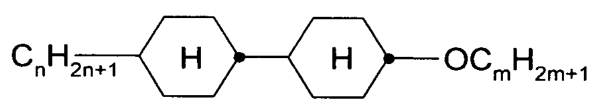
CCP-V-m 

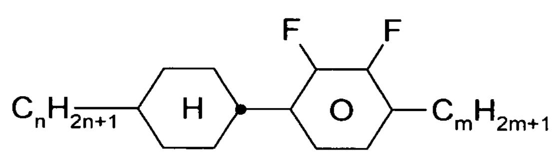
CCP-Vn-m 

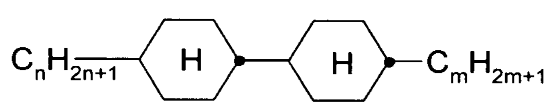
CPYC-n-m 

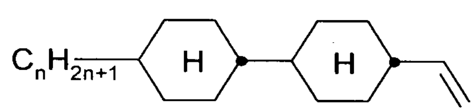
CYYC-n-m 

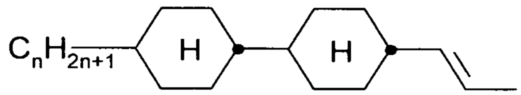
CCYY-n-(O)m 

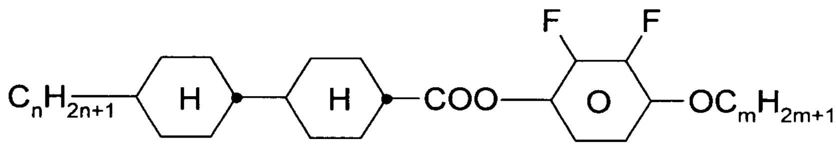
CCH-nOm 

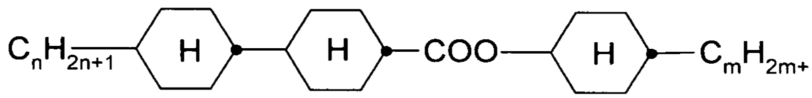
CY-n-m 

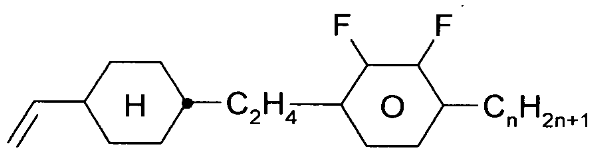
CCH-nm 

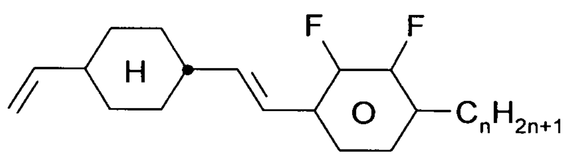
CC-n-V 

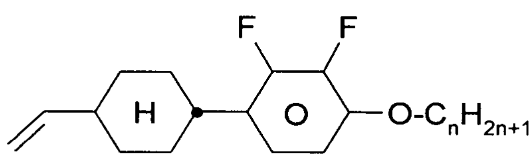
CC-n-V1 

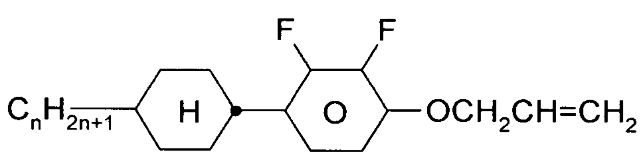
CP-nOmFF 

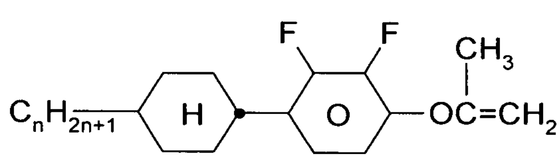
CH-nm 

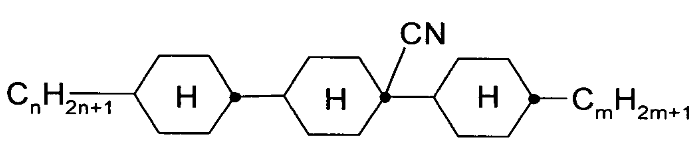
CEY-V-n 

CVY-V-n 

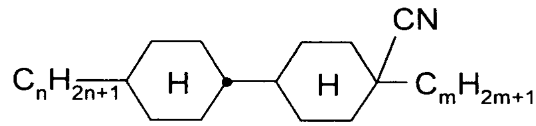
CY-V-On 

CY-n-O1V 

CY-n-OC(CH_3)=CH_2 

BCN-nm 

CCN-nm



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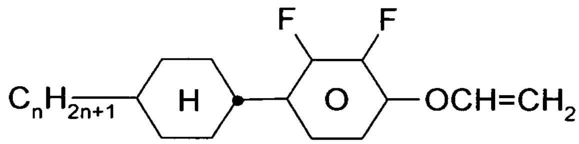
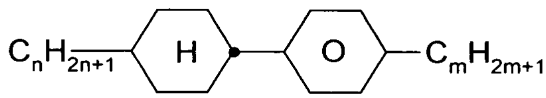
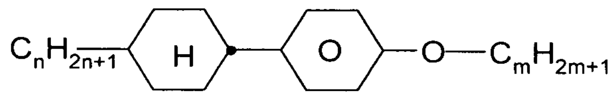


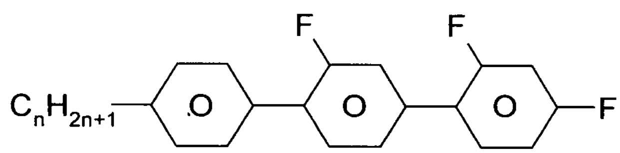
PCH-nm



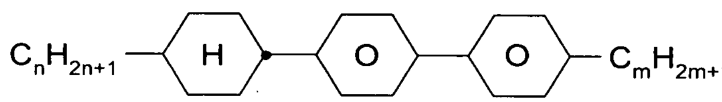
PCH-nOm



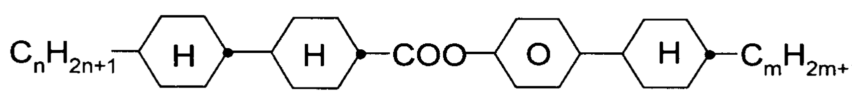
PGIGI-n-F



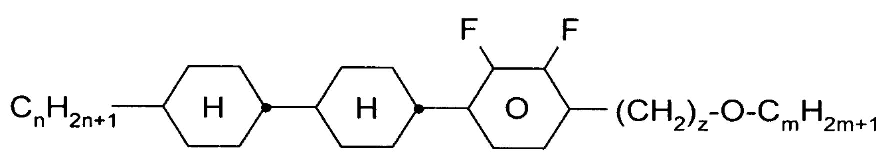
BCH-nm



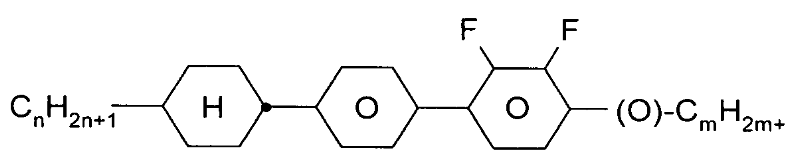
CCPC-nm

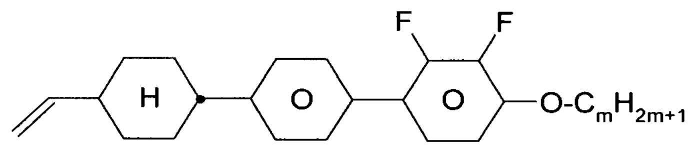


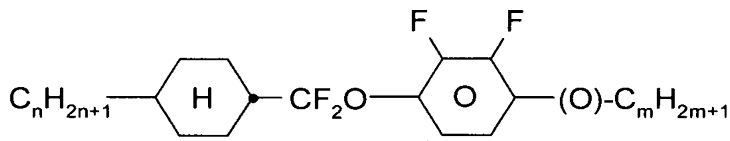
CCY-n-zOm

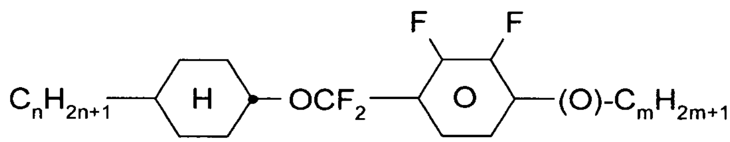


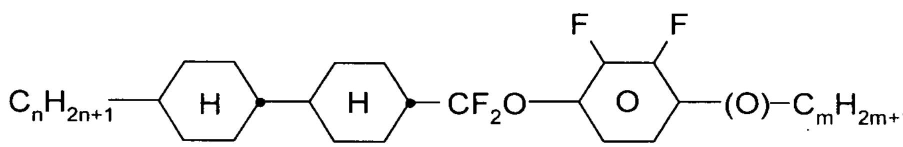
CPY-n-(O)m

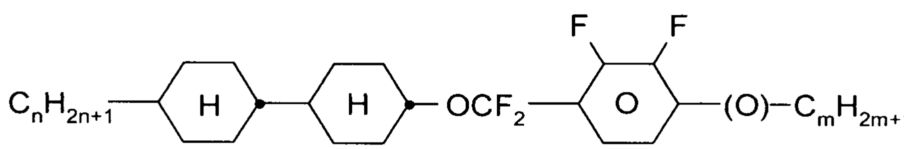


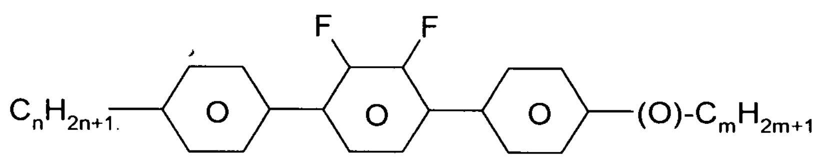
CPY-V-Om 

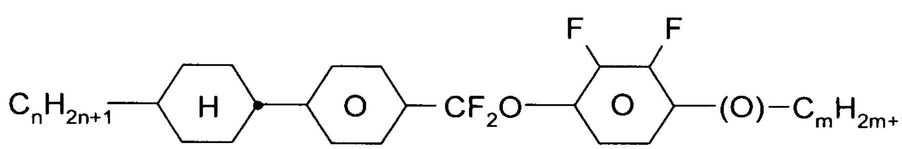
CQY-n-(O)m 

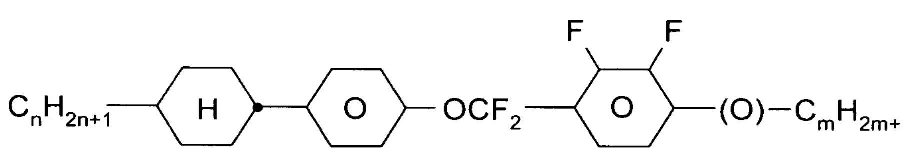
CQIY-n-(O)m 

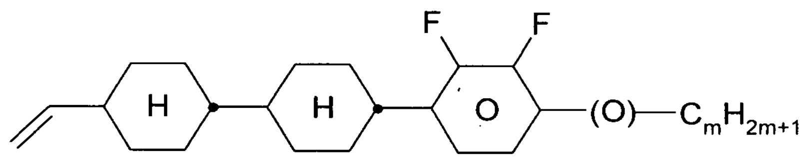
CCQY-n-(O)m 

CCQIY-n-(O)m 

PYP-n-(O)m 

CPQY-n-(O)m 

CPQIY-n-(O)m 

CCY-V-(O)m 

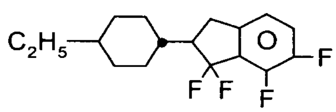
Furthermore,

V_o	denotes the threshold voltage, capacitive [V] at 20°C
Δn	denotes the optical anisotropy measured at 20°C and 589 nm
$\Delta\varepsilon$	denotes the dielectric anisotropy at 20°C and 1 kHz
cp.	denotes the clearing point [°C]
γ_1	denotes the rotational viscosity measured at 20°C [mPa·s]
LTS	denotes the low temperature stability, determined in test cells

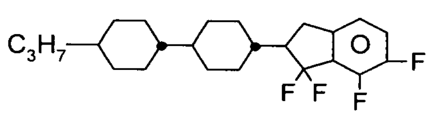
The display used for measurement of the threshold voltage has two plane-parallel outer plates at a separation of 20 μm and electrode layers with overlying alignment layers of SE-1211 (Nissan Chemicals) on the insides of the outer plates, which effect a homeotropic alignment of the liquid crystals.

Mixture Examples

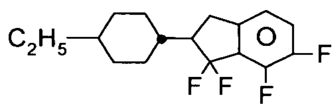
Example 1

CY-3-O2	19.0%	Clearing point [°C]:	74.5
CY-5-O2	12.0%	Δn [589 nm, 20°C]:	+0.0815
CCY-3-O3	7.0%	$\varepsilon_{\parallel}$ [1 kHz, 20°C]:	3.6
CCY-4-O2	7.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-3.6
CPY-2-O2	7.0%	γ_1 [mPa·s, 20°C]:	102
CC-5-V	20.0%	V_0 [V]	2.12
CC-3-V1	12.0%	LTS at -30°C:	nematic > 1000 h
CCP-V-1	5.0%		
CCH-35	5.0%		
	6.0%		

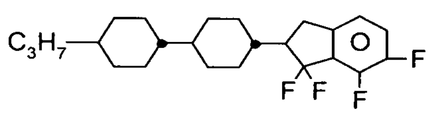
Example 2

CY-3-O2	17.0%	Clearing point [°C]:	75.0
CY-5-O2	6.0%	Δn [589 nm, 20°C]:	+0.0820
CCY-3-O3	12.0%	$\varepsilon_{\parallel}$ [1 kHz, 20°C]:	3.8
CCY-4-O2	8.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-3.7
CPY-2-O2	9.0%	γ_1 [mPa·s, 20°C]:	104
CC-5-V	20.0%	V_0 [V]	2.10
CC-3-V1	12.0%		
CCP-V-1	4.0%		
CCH-35	5.0%		
	7.0%		

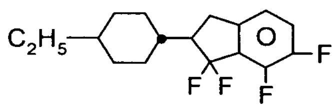
Example 3

CY-3-O2	20.0%	Clearing point [°C]:	74.0
CY-5-O2	11.0%	Δn [589 nm, 20°C]:	+0.0812
CCY-3-O3	5.0%	$\varepsilon_{\parallel}$ [1 kHz, 20°C]:	3.6
CCY-4-O2	6.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-3.3
CPY-2-O2	6.0%	γ_1 [mPa·s, 20°C]:	92
CC-5-V	20.0%	V_0 [V]	2.23
CC-3-V1	12.0%	LTS at -30°C:	nematic > 1000 h
CCP-V-1	9.0%		
CCH-35	5.0%		
	6.0%		

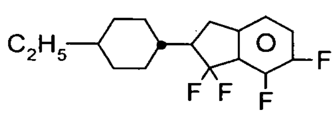
Example 4

CY-3-O2	10.0%	Clearing point [°C]:	73.5
CY-5-O2	10.0%	Δn [589 nm, 20°C]:	+0.0827
CCY-3-O3	12.0%	$\varepsilon_{\parallel}$ [1 kHz, 20°C]:	3.8
CCY-4-O2	6.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-3.3
CPY-2-O2	12.0%	γ_1 [mPa·s, 20°C]:	97
CC-5-V	20.0%	V_0 [V]	2.12
CC-3-V1	12.0%	LTS at -40°C:	nematic > 1000 h
CCP-V-1	3.0%		
	7.0%		
CC-4-V	8.0%		

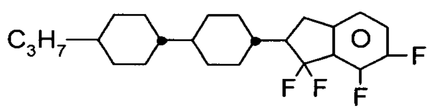
Example 5

CY-3-O4	20.0%	Clearing point [°C]:	83.5
CY-5-O2	11.0%	Δn [589 nm, 20°C]:	+0.1022
CCY-3-O3	10.0%	$\varepsilon_{\parallel}$ [1 kHz, 20°C]:	3.8
CPY-2-O2	12.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-4.7
CPY-3-O2	12.0%	γ_1 [mPa·s, 20°C]:	167
CCH-35	5.0%	$\gamma_1/\Delta n^2$ [Pa·s]:	16.0
CC-5-V	11.0%	V_0 [V]	1.91
CC-3-V1	9.0%	LTS at -30°C:	nematic > 1000 h
BCH-32	4.0%		
	6.0%		

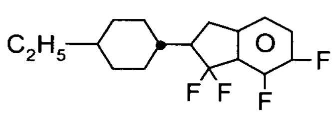
Example 6

CY-3-O4	20.0%	Clearing point [°C]:	79.5
CY-5-O2	13.0%	Δn [589 nm, 20°C]:	+0.1109
CCY-3-O3	10.0%	$\varepsilon_{\parallel}$ [1 kHz, 20°C]:	4.0
CPY-2-O2	12.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-5.1
CPY-3-O2	11.0%	γ_1 [mPa·s, 20°C]:	178
CC-3-V1	10.0%	$\gamma_1/\Delta n^2$ [Pa·s]:	14.5
CC-5-V	11.0%	V_0 [V]	1.79
PYP-2-3	7.0%	LTS at -30°C:	nematic > 1000 h
	6.0%		

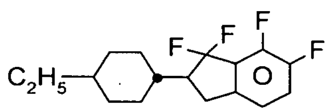
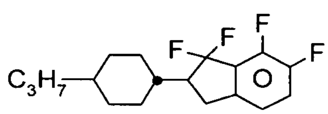
Example 7

CY-3-O4	18.0%	Clearing point [°C]:	79.5
CY-5-O2	8.0%	Δn [589 nm, 20°C]:	+0.1097
CCY-3-O3	12.0%	$\varepsilon_{\parallel}$ [1 kHz, 20°C]:	4.2
CCY-4-O2	4.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-5.2
CPY-2-O2	12.0%	γ_1 [mPa·s, 20°C]:	180
CPY-3-O2	12.0%	$\gamma_1/\Delta n^2$ [Pa·s]:	14.9
CC-3-V1	8.0%	V_0 [V]	1.77
CC-5-V	12.0%		
PYP-2-3	7.0%		
	7.0%		

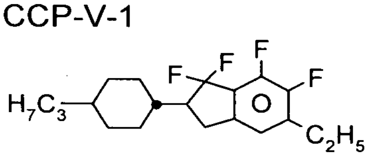
Example 8

CY-3-O4	14.0%	Clearing point [°C]:	72.0
CY-5-O2	12.0%	Δn [589 nm, 20°C]:	+0.0888
CY-5-O4	12.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-4.3
CCY-3-O3	12.0%	γ_1 [mPa·s, 20°C]:	138
CPY-2-O2	10.0%	$\gamma_1/\Delta n^2$ [Pa·s]:	17.5
CPY-3-O2	6.0%	V_0 [V]	1.80
CCH-35	6.0%		
CC-3-V1	9.0%		
CC-5-V	13.0%		
	6.0%		

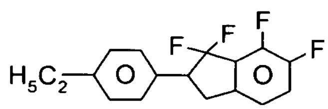
Example 9

CY-3-O2	8.0%	Clearing point [°C]:	85.0
CY-5-O2	8.0%	Δn [589.3 nm, 20°C]:	+0.0822
CCY-3-O2	3.0%	$\varepsilon_{\parallel}$ [1 kHz, 20°C]:	3.9
CCY-3-O3	12.0%	Δε [1 kHz, 20°C]:	-3.9
CCY-4-O2	10.0%	γ_1 [mPa·s, 20°C]:	124
CPY-2-O2	3.0%	V_0 [V]	2.18
CC-5-V	20.0%		
CC-3-V1	12.0%		
CCP-V-1	10.0%		
	6.0%		
	8.0%		

Example 10

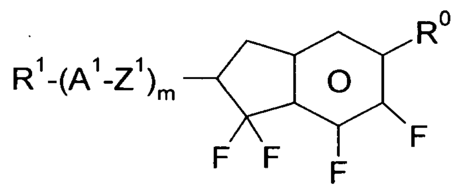
CY-3-O2	6.0%	Clearing point [°C]:	85.0
CY-5-O2	12.0%	Δn [589.3 nm, 20°C]:	+0.0825
CCY-3-O2	5.0%	Δε [1 kHz, 20°C]:	-3.9
CCY-3-O3	12.0%	γ_1 [mPa·s, 20°C]:	125
CCY-4-O2	10.0%	V_0 [V]	2.18
CPY-2-O2	3.0%		
CC-5-V	20.0%		
CC-3-V1	12.0%		
CCP-V-1	10.0%		
	10.0%		

Example 11

CY-3-O4	10.0%	Clearing point [°C]:	81.0
CCY-3-O3	2.0%	Δn [589.3 nm, 20°C]:	+0.1280
CPY-2-O2	12.0%	$\Delta\varepsilon$ [1 kHz, 20°C]:	-3.6
CPY-3-O2	12.0%	γ_1 [mPa·s, 20°C]:	135
CC-5-V	20.0%	V_0 [V]	2.15
CC-3-V1	11.0%		
BCH-32	2.0%		
PYP-2-3	10.0%		
PYP-2-4	11.0%		
	10.0%		

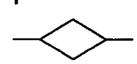
Patent Claims

1. Liquid-crystalline medium based on a mixture of polar compounds having negative dielectric anisotropy, characterised in that it comprises at least one compound of the formula I



I

in which

R^0 and R^1 each, independently of one another, denote H, an alkyl or alkenyl radical having up to 15 C atoms which is unsubstituted, monosubstituted by CN or CF_3 or at least monosubstituted by halogen, where, in addition, one or more CH_2 groups in these radicals may be replaced by -O-, -S-,  , -C≡C-, -OC-O- or -O-CO- in such a way that O atoms are not linked directly to one another,

A^1

a) denotes a 1,4-cyclohexenylene or 1,4-cyclohexylene radical, in which one or two non-adjacent CH_2 groups may be replaced by -O- or -S-,

b) denotes a 1,4-phenylene radical, in which one or two CH groups may be replaced by N,

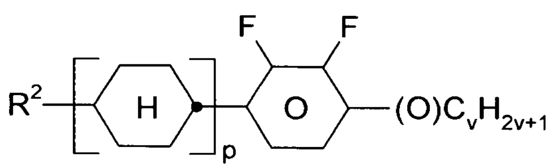
c) denotes a radical from the group consisting of piperidine-1,4-diyl-, 1,4-bicyclo[2.2.2]octylene-, a naphthalene-2,6-diyl, decahydronaphthalene-2,6-diyl, 1,2,3,4-tetrahydronaphthalene-2,6-diyl, phenanthrene-2,7-diyl and fluorene-2,7-diyl,

where the radicals a), b) and c) may be mono- or polysubstituted by halogen atoms,

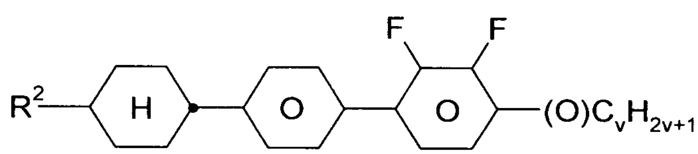
Z^1 denotes -CO-O-, -O-CO-, $-CF_2O-$, $-OCF_2-$, $-CH_2O-$, $-OCH_2-$, $-CH_2CH_2-$, $-(CH_2)_4-$, $-C_2F_4-$, $-CH_2CF_2-$, $-CF_2CH_2-$, -CF=CF-, -CH=CF-, -CF=CH-, -CH=CF-, -CF=CH-, -CH=CH-, -C≡C- or a single bond, and

m denotes 0, 1 or 2.

2. Liquid-crystalline medium according to Claim 1, characterised in that it additionally comprises one or more compounds of the formulae IIA and/or IIB:

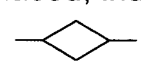


IIA



IIB

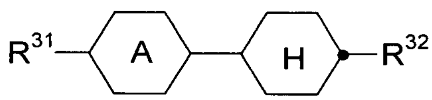
in which

R^2 denotes an alkyl or alkenyl radical having up to 15 C atoms which is unsubstituted, monosubstituted by CN or CF_3 or at least monosubstituted by halogen, where, in addition, one or more CH_2 groups in these radicals may each be replaced, independently of one another, by -O-, -S-,  , -C≡C-, -CO-, -CO-O-, -O-CO- or -O-CO-O- in such a way that O atoms are not linked directly to one another,

p denotes 1 or 2, and

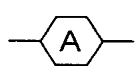
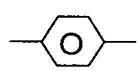
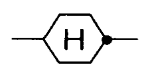
v denotes 1 to 6.

3. Liquid-crystalline medium according to Claim 1 or 2, characterised in that it additionally comprises one or more compounds of the formula III

 III

in which

R^{31} and R^{32} each, independently of one another, denote a straight-chain alkyl, alkenyl, alkylalkoxy or alkoxy radical having up to 12 C atoms, and

 denotes  or  .

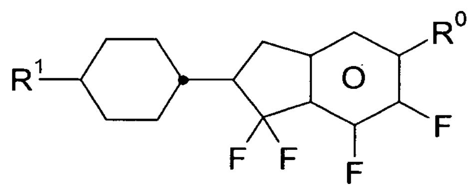
4. Liquid-crystalline medium according to one of Claims 1 to 3, characterised in that it comprises one, two, three, four or more compounds of the formula I.

5. Liquid-crystalline medium according to one of Claims 1 to 4, characterised in that the proportion of compounds of the formula I in the mixture as a whole is at least 5% by weight.

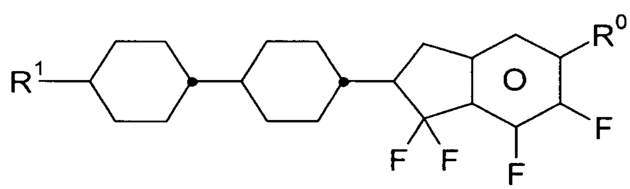
6. Liquid-crystalline medium according to one of Claims 1 to 5, characterised in that the proportion of compounds of the formulae IIA and/or IIB in the mixture as a whole is at least 20% by weight.

7. Liquid-crystalline medium according to one of Claims 1 to 6, characterised in that the proportion of compounds of the formula III in the mixture as a whole is at least 5% by weight.

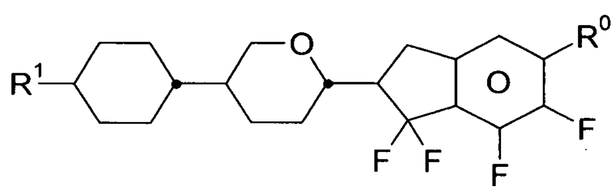
8. Liquid-crystalline medium according to one of Claims 1 to 7, dadurch characterised in that it comprises at least one compound selected from the formulae I1 to I12



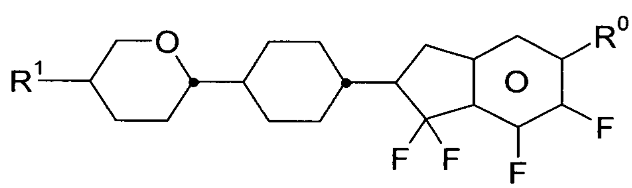
I1



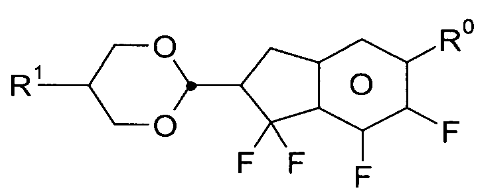
I2



I3



I4



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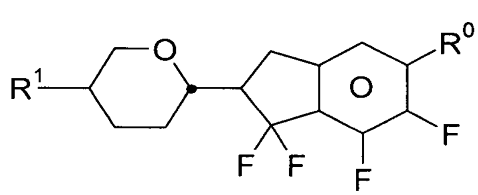

I6

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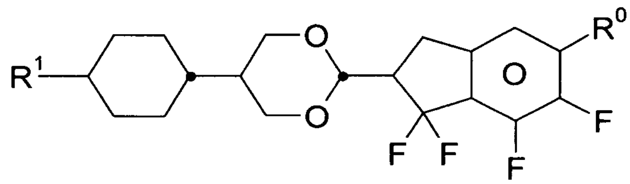

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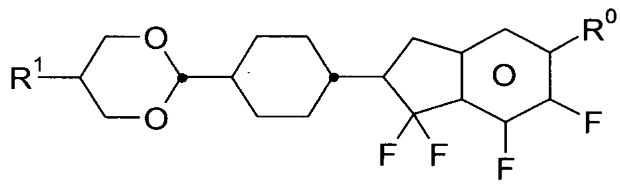

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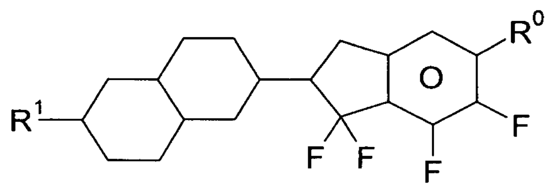

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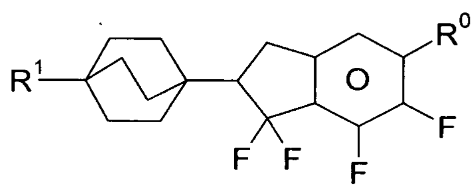
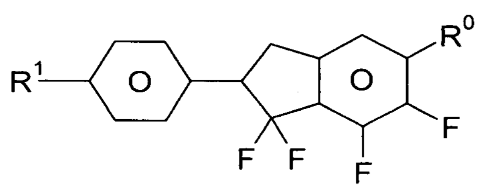
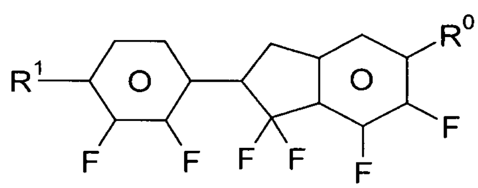


I10



I11



I12

in which

R^0 and R^1 have the meanings indicated in Claim 1.

9. Liquid-crystalline medium according to one of Claims 1 to 8, characterised in that it essentially consists of

   5-30 % by weight of one or more compounds of the formula I

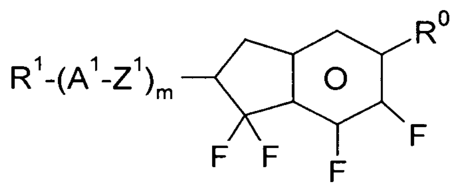
   and

   20-70 % by weight of one or more compounds of the formulae IIA and/or IIB.

10. Electro-optical display with active-matrix addressing based on the ECB, PALC or IPS effect, characterised in that it contains, as dielectric, a liquid-crystalline medium according to one of Claims 1 to 9.

Abstract

The invention relates to a liquid-crystalline medium based on a mixture of polar compounds having negative dielectric anisotropy, which comprises at least one compound of the formula I



I

in which

R^0, R^1, A^1, Z^1 and m have the meanings indicated in Claim 1,

and to the use thereof for an active-matrix display based on the ECB, PALC or IPS effect.